BASOV, N.G.

The molecular oscillator consists of three components: a source for the molecular beam, a sorting system, and a cavity resonator. The molecular beam is produced with the aid of a copper foil grating, having 0.05 by 0.05 mm openings spaced 0.05 mm apart. Such an oscillator was tested for 3 hours of continuous operation.

The author thanks A. M. Prokhorov, A. N. Orayevskiy, K. K. Svidzinskiy, G. M. Starshinin, and K. K. Yermoshina for their assistance. (U)

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BASOV, N.G.

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Investigation of performance of molecular generator. N. G. Basov. *Pribory i Tekh. Eksperimenta* 1957, No. 1, 77-82; cf. preceding abstr.—The performance of a mol. generator which employs a beam of NH_3 mols. has been investigated. Results are presented on the power of radiation, monochromatic oscillation, and the stability of frequency.

A. Kremheller

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SOV/141-58-4-6/26

AUTHORS: Basov, N.G. and Orayevskiy, A.N.

TITLE: The Possibilities of Making a Sealed Maser Using ND_3, NH_2D and NHD_2 Molecules (O vozmozhnosti sozdaniya otpayannogo molekulyarnogo generatora s ispol'zovaniyem molekul ND_3, NH_2D i NHD_2)

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Radiofizika, 1958, Nr 4, pp 63-68 (USSR)

ABSTRACT: The possibility is considered of preparing molecules in active state in three energy levels (Fig 1) by using auxiliary radiation. The energies of the three levels are given in Eq (1). The theory and design are given of an oscillator using deuterated ammonia. Under conditions of thermodynamic equilibrium, the number of molecules N_3 in level three is greater than the number of molecules in N_2 and N_1 in levels two and one, since in this case the number of molecules in a

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level is determined by the Boltzmann factor. An auxiliary radiation whose frequency is given by Eq (2) excites the molecules from level three into level one creating a surplus of molecules in level one compared with those in level two (see Fig 1a) or in level two compared with level three (see Fig 1b). These respective transitions 1-2 and 2-3 are used to excite a resonator whose frequency is given by Eq (3) for the case in Fig 1a or Eq (4) for the case of Fig 1b. The greatest number of active molecules is obtained under conditions of saturation and the actual numbers are given for the two cases by Eq (5). If the gas is illuminated by monochromatic radiation the saturation conditions must satisfy Eq (6). The minimum width of the spectral line from the maser is given by the Doppler width of the line in the basic transition. If the gas pressure is too high the line increases in width and if the pressure is too low then the number of active molecules falls off. The optimum pressure is

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given by Eq (7). If a monochromatic auxiliary radiation is used however, considerable line broadening occurs; this may be avoided by using as auxiliary radiation a group of frequencies whose spacing is of the order of the basic Doppler width, in this case the saturation condition is given by Eq (8). Line broadening still occurs but it is now significantly less. The energy stored in the resonator is given by Eq (9) and, depending on the quality factor of the resonator, the auxiliary power required is given by Eq (10). This last amount is considerably less than that required when using monochromatic illumination. The best type of resonator to use is a cylindrical one supporting a mode E_{001}. The conditions for self-excitation of a maser depend neither on the type of oscillations supported nor on the pressure and can be written as Eq (11). The rotational transition for ND_3 has a frequency of 3×10^{11} c/s and higher. The frequency

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increases with the quantum number J. Power is very difficult to obtain at these frequencies and in practice low quantum numbers are therefore to be preferred. It is therefore proposed to use as the low-frequency transition $1_1^- - 2_1^+$ and for the fundamental transition $1_1^+ - 1_1^-$. The leading particulars of the oscillator are calculated to be as follows: fundamental frequency, 1598 x 10 Mc/s; auxiliary frequency, 6.2×10^{11} c/s; Doppler width of the line at fundamental frequency 2.2×10^3 c/s; Doppler width at the auxiliary frequency 8.5×10^5 c/s; resonator quality necessary to maintain oscillations 3×10^3; auxiliary power 4×10^{-5} watts; number of active molecules 6×10^{15} molecules per second; power output 10^{-10} watts. It is reckoned that under practical conditions the stability of oscillation would be approximately one part in 10^8. The fundamental difficulty in making an ND_3 maser is the difficulty of obtaining sufficient power at a wavelength of 0.5 mm.

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The Possibilities of Making a Sealed Maser Using ND_3, NH_2D and NHD_2 Molecules

Molecules of partially deuterated ammonia have an asymmetrical spin and therefore have a richer spectrum. Table 1 shows values of the frequencies of the basic and auxiliary radiations for molecules NH_2D and NHD_2 and also the intensities of the lines. Table 2 gives the parameters of masers using the lines given in Táble 1. There are 2 figures and 2 tables and 13 references, 7 of which are Soviet.

ASSOCIATION: Fizicheskiy institut imeni P.N.Lebedeva AN SSSR (Physics Institute imeni P.N.Lebedev, AS USSR)

SUBMITTED: 10th November 1957

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26-58-7-4/48

AUTHORS: Basov, N.G. and Prokhorov, A.M., Doctors of Physico-Mathematical Sciences

TITLE: Molecular Generators and Amplifiers (Molekulyarnyye generatory i usiliteli)

PERIODICAL: Priroda, 1958, Nr 7, pp 24-32 (USSR)

ABSTRACT: During the past 5 years, new methods of generation and amplifying electromagnetic waves have appeared that are based on the induced radiations of excited molecules. These methods were suggested and developed independently in the Physical Institute imeni P.N. Lebedev of the AS USSR - Moscow, by N.G. Basov and A.M. Prokhorov, as well as in the Columbia University in the USA. In 1940, V.A. Fabrikant pointed out the possibility of negative absorption in the optical wave range in a gas discharge. In new devices the principal role in the generation process of electromagnetic oscillations is played by the energy that is connected with the inner motion of atoms or molecules. Thus, the so-called molecular generators and amplifiers are subject to the application of the laws of quantum mechanics and not to those of the classical electrodynamics. In many works devoted to the ampli-

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Molecular Generators and Amplifiers 26-58-7-4/48

fication and generation of centimeter waves, the phenomenon of the paramagnetic resonance discovered by the Soviet scientist Ye.K. Zavoyskiy was used. Soviet research, similar to relevant steps in other countries, is centered on the molecular generator operating on an ammonia beam, which may serve as the standard source of highly stable oscillations. This has already become evident after only 2 to 3 years of relevant research. For a small period of time a relative stability of 10^{-12} has been obtained, but an absolute stability of 10^{-9} can be considered as a standard performance of a molecular generator. This makes it useful in the field of radio-navigation, radar, and radiogeodesy, and in the production of highly accurate watches. The theory of a different speed of time depending on the distance from the earth's surface could be proved by comparing the operation of molecular generators located in artificial earth satellites and on the earth's surface. The frequency difference (time speed) per 1 km of vertical distance from the earth's surface would be a frequency of 10^{-13}. Molecular amplifiers will be of use in the solution of merely scientific and also practical problems, such as a deeper penetration of the universe by means of observation, observation of the weak radiation of various

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atoms and free radicals in the universe.
There are 11 diagrams, 1 figure, 1 photo and 3 Soviet references.

ASSOCIATION: Fizicheskiy institut imeni P.N. Lebedeva AN USSR - Moscow (Physics Institute imeni P.N. Lebedev AS USSR - Moscow)

1. Electromagnetic waves--Propagation 2. Electromagnetic waves--Intensity 3. Molecules--Excitation

BASOV, N.G.; SVIDZINSKIY, K.K.

Designing a molecular oscillator based on a ND_3 molecular beam. Izv.vys.ucheb.zav.; radiofiz. 1 no.2:89-94 '58. (MIRA 11:11)

1. Fizicheskiy institut AN SSSR.
(Microwaves)

BASOV, N.G.; ORAYEVSKIY, A.N.

Possibility of making a sealed-off molecular oscillator with utilization of ND_3, NH_2D, and NHD_2.molecules. Izv.vys.ucheb.zav.; radiofiz. 1 no.4:63-68 '58. (MIRA 12:5)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR.
(Microwaves)

BASOV, N.G.; MURIN, I.D.; PETROV, A.P.; PROKHOROV, A.M.; SHTRANIKH, I.V.

Molecular clock. Izv.vys.ucheb.zav.; radiofiz. 1 no.3:50-53 '58. (MIRA 12:1)

1. Fizicheskiy institut imeni P.N. Lebedeva AN SSSR.
(Time measurements) (Molecules--Vibration)

AUTHOR: Basov, N.G. 109-3-2-24/26

TITLE: ~~The Condition of~~ Self-excitation of a Molecular Free-space Oscillator (Ob uslovii Samovozbuzhdeniya molekulyarnogo generatora bez ob"yemnogo rezonatora)(Letter to the Editor) (Pis'ma v redaktsiyu)

PERIODICAL: Radiotekhnika i Elektronika, 1958, Vol.III, No.2, pp. 297 - 298 (USSR).

ABSTRACT: The problem is analysed as follows: it is shown that a spherical sample, having N_0 active molecules per unit volume and having a radius R , radiates a power W which can be expressed by Eq.(1). On the other hand, the power can also be expressed by Eq.(2) and the condition of oscillation by Eq.(3). Since the probability of the emission of a quantum w is given by Eq.(4), the amplitude of the oscillations can be expressed by Eq.(5), from which it follows that the condition of the self-excitation is given by Eq.(6). The following notation is used in the above equations: ω_{mn} is the natural frequency of a molecule, $\hbar$ is the Planck constant, E the amplitude of the field, c is the velocity of light, d_{mn} is a matrix element of the dipole moment and τ is the relaxation time of the molecules. There are 8 references, 3 of which are Russian, 4 English and 1 French.

AUTHOR: Basov, N.G. and Petrov, A.P. 109-3-2-25/26

TITLE: The Relative Frequency Stability of Molecular Oscillators (Ob otnositel'noy stabil'nosti chastoty molekulyarnykh generatorov)

PERIODICAL: Radiotekhnika i Elektronika, 1958, Vol.III, No.2, pp. 298-299 (USSR).

ABSTRACT: The problem was investigated experimentally by means of the equipment shown in the figure on p.299. The results are shown graphically in Fig.2 for two different oscillators; the staircase-like curve in the figure shows the frequency deviation in c/s as a function of time in minutes. From this, it is seen that over a period of 16 minutes, ~~the~~ difference frequency did not vary more than $\pm$ 0.4 c/s. The relative frequency stability of the oscillators over the above period was of the order of 10^{-11}.
There 2 figures and 1 Russian reference.

ASSOCIATION: Institute of Physics im. P.N. Lebedev AS USSR (Fizicheskiy institut im. P.N. Lebedeva AN SSSR)

SUBMITTED: July 15, 1957
AVAILABLE: Library of Congress

Card 1/1 1. Oscillators-Frequency measurement-Stability

Sov/51-4-4-18/24

AUTHORS: Barchukov, A.I. and Basov, N.G.

TITLE: Measurements of the Frequencies and Intensities of the Hyperfine Structure Lines of CH_3I (Transition $J = 0 \rightarrow 1$)

(Izmereniye chastot i intensivnostey liniy sverkhtonkoy struktury CH_3I (perekhod $J = 0 \rightarrow 1$))

PERIODICAL: Optika i Spektroskopiya, 1958, Vol IV, Nr 4, p 532 (USSR).

ABSTRACT: Complete translation. Both frequencies and absolute intensities of the hyperfine structure lines of the $C^{12}H_3I^{127}$ molecule were measured. The results of measurements are given in the table:

Transition $F \rightarrow F'$	Frequency in Mc/s Measured	Frequency in Mc/s Calculated	Intensity (in cm^{-1})
5/2 3/2	15275.87±0.05	15275.82	2.3×10^{-6}
5/2 5/2	14695.22±0.05	14695.22	3.5×10^{-6}
5/2 7/2	15100.74±0.05	15100.70	4.3×10^{-6}

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Sov/51-4-4-18/24

Measurements of the Frequencies and Intensities of the Hyperfine Structure Lines of CH_3I (Transition $J = 0 \rightarrow 1$)

Calculation of the frequencies was carried out with inclusion of corrections of the second approximation of the perturbation theory, using a value for the rotational constant $B = 7501.29$ Mc/s and the quadrupole coupling constant $eQq = -1934$ Mc/s. The values of these constants agree with the constants given in Refs 1-3. The absolute intensities of lines were measured by the method described in Ref 4. The measured relative intensities agree within 15% with the calculated values based on spin equal to 5/2. There are 1 table and 4 references, 1 of which is Soviet and 3 in English.

ASSOCIATION: Fizicheskiy institut im.P.N.Lebedeva AN SSSR (Physics Institute im.P.N.Lebedev, Ac.Sc. USSR)

SUBMITTED: July 22, 1957

Card 2/2 1. Methyl iodides--Spectrographic analysis

AUTHORS: Basov, N.G. and Osipov, B.D. SOV/51-4-6-14/24

TITLE: Emission Line of the Transition $F = 5/2 \rightarrow 3/2$, $J = 1$, $K = 1$ in the Rotational Spectrum of the CH_3I^{127} molecule. (Liniya ispuskaniya perekhoda $F = 5/2 \rightarrow 3/2$, $J = 1$, $K = 1$ vrashchatel'nogo spektra molekuly CH_3J^{127})

PERIODICAL: Optika i Spektroskopiya, 1958, Vol IV, Nr 6, pp 795-797 (USSR)

ABSTRACT: Basov and Prokhorov (Ref 1) showed that it is possible to obtain active molecules in a system with three energy levels. This possibility was experimentally realized in the work reported in Ref 2 on levels of paramagnetic electron resonance in a crystal of gadolinium ethyl sulphate. A similar system of levels may be selected from the rotational spectrum of a molecule which possesses a sufficiently clear hyperfine structure (Fig 1). It is then possible to use a gaseous substance at low pressures and to obtain high resolving power. In this way an emission line (shown as ν_{12} in Fig 1) may be obtained. Experimental observations may be made in a spectroscope with a cavity resonator, as well as in a spectroscope with a waveguide absorption cell. The second method is more convenient when the form of the spectral line is studied, but it

Emission Line of the Transition $F = 5/2 \rightarrow 3/2$, $J = 1$, $K = 1$ in the Rotational Spectrum of the CH_3I^{127} molecule SOV/51-4-6-14/24

requires high powers of auxiliary radiation (ν_{13} in Fig 1). Observation of the ν_{12} transition in the presence of auxiliary radiation makes it possible to increase the intensity of the ν_{12} line by a factor of $(1/2)(\nu_{13}/\nu_{12})$. Periodic variation of intensity of frequency of the auxiliary radiation produces modulation of the level 1 (Fig 1) population which makes observation of the ν_{12} transition much easier. The present paper reports observations on the emission line of the transition $F = 5/2 \rightarrow 3/2$, $J = 1$, $K = 1$, between hyperfine structure levels in the rotational spectrum of CH_3I^{127}. The apparatus used is shown schematically in Fig 2. A superheterodyne spectroscope with a coaxial cavity resonator 1 was used. The external wall of the resonator was made of a wire grid which was transparent to high-frequency radiation. This made it possible to tune independently at high and low frequencies. Auxiliary radiation was produced by a klystron 3, whose frequency was varied in a saw-toothed fashion near 30215 Mc/s. When the frequency of the klystron passed through the resonance frequency of the absorption line $\nu_{13} = 30216$ Mc/s, the emission line was observed by change of power reflected from the coaxial resonator,

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Emission Line of the Transition $F = 5/2 \rightarrow 3/2$, $J = 1$, $K = 1$ in the Rotational Spectrum of the CH_3I^{127} molecule SOV/51-4-6-14/24

tuned to the frequency of $\nu_{12} = 292.45$ Mc/s. The coaxial resonator was insulated from the external resonator and served as the electrode for Stark modulation. In this way the absorption line ν_{13} was observed on a control oscilloscope (10 in Fig 2). The intensity of the emission line reached a maximum of the order of 10^{-8} cm^{-1} at (3-5) x 10^{-3} mm Hg. Power of the auxiliary radiation was of the order of several mW. The results obtained show that the spectroscope used makes it possible to make about 100 times more sensitive measurements than the usual method of observation of absorption lines (Ref 4). To increase the resolving power it would be necessary to use a non-monochromatic auxiliary radiation or spatial separation of the field. The authors thank A.V. Dudenkova, Yu. P. Zakharov and G. Mishukov for help in this work. There are 2 figures and 4 references, 3 of which are American and 1 Soviet.

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ASSOCIATION: Fizicheskiy institut im. P.N. Lebedeva, AN SSSR (Physics Institute imeni P.N. Lebedev, Academy of Sciences of the U.S.S.R.)

SUBMITTED: November 19, 1957

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SOV/142-2-1-1/22

AUTHORS: Basov, N.G., and Orayevskiy, A.N.

TITLE: Quantum Radio Engineering (Kvantovaya radiotekhnika)

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy - radiotekhnika, 1959, Vol 2, Nr 1, pp 3-17 (USSR)

ABSTRACT: The authors present a brief review of paper on quantum radio pnysics and quantum radio engineering, stating that about 200 scientific papers were published on this subject sofar. They emphasize especially the physical principles of the new methods of generating and amplifying radio waves. The quantum method of generating and amplifying radio waves was suggested independently by the Fizicheskiy institut imeni P.N. Lebedeva AN SSSR (Institute of Physics imeni P.N. Lebedev, AS USSR) by N.G. Basov and A.M. Prokhorov and also by the Columbia University by Gordon, Zeiger and Townes. This review does not contain all possible applications of the new method of generating and amplifying radio waves. For a more detailed consideration of the problems

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Quantum Radio Engineering SOV/142-2-1-1/22

mentioned in this article, the authors refer the reader to 54 references. Only 21 references are Russian origin, whereby 10 of the latter were published by N.G. Basov and coworkers and two by A. M. Prohorov. In their review, the authors consider the physical principles of molecular radio wave generation and amplification, mentioning the experiment of Stern and Gerlach (Shtern, Gerlakh). Presently, two different molecular generator designs have been developed, one by the Columbia University and one by FIAN, both using a beam of ammonia (NH_3) molecules. In the FIAN method, a special diaphragm is used, cooled by liquid nitrogen, whereby the electrodes of the quadrupole capacitor are not cooled. Then the authors review the development of solid-state maser amplifiers. Finally, the authors consider some possible applications of molecular systems, which have not been realized as yet. They mention the generation and amplification of millimeter and sub-millimeter waves, whereby the design of cavity resonators

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BASOV, N.G.

21 (0), 24 (0)
SOV/89-7-2-18/24

AUTHOR: Tyagunov, G. A.

TITLE: Scientific Conference of the MIFI (Nauchnaya konferentsiya MIFI)

PERIODICAL: Atomnaya energiya, 1959, Vol 7, Nr 2, pp 176-177 (USSR)

ABSTRACT: The yearly scientific meeting was held from 17 April to 15 May 1959 in the Moskovskiy inzhenerno-fizicheskiy institut (Moscow Physical Engineering Institute). More than 600 participants from 100 different institutes attended the 2 plenary and 18 sectional conferences. A total of 148 lectures were held. The following lectures are specially mentioned: N. K. Romanovskiy on the thermo-nuclear examinations, N. G. Basov on the physical foundations of molecular generators and amplifiers, A. I. Leypunskiy on the construction of a fast reactor, I. Ya. Pomeranchuk on the theory of the peripheral collision of mesons and nucleons, A. B. Migdal on superfluidity and momentum of inertia of the nuclei, A. S. Kompaneyets on the strong electromagnetic gravity wave, V. I. Gol'danskiy on levels which are excited within the nucleus shell and methods of comprehending them, L. L. Rozental' and L. A. Prokhorova on the analysis of the possible experiments for the determination of the measurements of the μ-mesons, Ye. I. Dianov-Klokov on the spectrum of liquid and crystalline hydrogen under pressure (8000-10000 atm) and an instrument for measuring the absorption curves, Yu. A. Lyapidevskiy and O. V. Olsnardina on new application possibilities of the diffusion chamber, A. V. Shal'nov on calculation methods for linear electron accelerators with migratory waves, P. A. Krasin, A. B. Kinerrin and A. I. Zaboyev on new theories of the electron capture under betatron conditions of the acceleration, Ya. G. Pratnov on optimum wave length for a generator, S. P. Lomnev and O. A. Tyagunov on magnetic focusing in a linear electron accelerator, O. A. Val'dner, F. A. Mitrovskiy, B. V. Zoria, Ye. V. Klain on the 3 mev linear accelerators of the MIFI, and V. V. Kuznetskiy, O. A. Val'dner, V. V. Kotov and I. N. Chesnokov on examination of the electron movement in the system of the elatron with consideration of the scattering fields, O. A. Krayev on impulse method for measuring the heat conduction capacity of liquids and the theory of this method, Ya. V. Khabakhpashev, Yu. K. Il'in and D. A. Chirov on heat transmission to the eutectic Na-K which flows in a circular space, V. I. Petrovichev on heat transmission to circulating mercury, V. V. Boyain on special conditions when working with a flat triode in the impulse technique, O. S. Pofurayev on calculation methods and construction of an impulse transformer for instruments with semi-conductor elements, Ya. A. Khetagurov on a possibility judge the characteristics of magnetic recording of impulses, B. I. Kal'nin on the element system for a universal digital computer, V. S. Malov on multiple control of the parameters of technologic processes, P. I. Popov on analysis of several systems with which physical energy apparatus can be automatically started, Yu. I. Topchayev on a method to examine the quality of a reactor control when the reactivity changes stepwise or linearily. G. A. Leont'yev and A. I. Yevstyukhin on examination of the iodine method of refining niobium and characteristics of the metal obtained, P. L. Gruzin and G. G. Ryabova on examination of the micro-distribution of carbon, tungsten, iron and other elements in zirconium and its alloys by use of autoradiography, G. B. Fedorov on determination of the sublimation heat of zirconium and nickel by using radioactive indicators and G. B. Fedorov and A. N. Semenikhin on determination of the diffusion coefficients of chromium, nickel, iron and chromium nickel steels. The literature for all these lectures will be published by the MIFI in a symposium.

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Card 3/3

AUTHOR: Basov, N.G. SOV/109-4-7-12/25

TITLE: Conversion of Mechanical Energy Into the UHF Energy in an UHF Motor

PERIODICAL: Radiotekhnika i elektronika, 1959, Vol 4, Nr 7, pp 1180 - 1184 (USSR)

ABSTRACT: The re-grouping of ions having a spin of 1/2 by means of an external magnetic field is considered. In the absence of the field, when the levels $M = \pm 1/2$ are degenerate, at the levels $+1/2$ and $-1/2$ there are identical numbers of ions. When the sample is placed into an external magnetic field, the energy of the ion which is oriented towards the field is increased, while the energy of the ion oriented against the field is reduced. As a result of the interaction of the ions with the lattice, re-distribution of the ion levels takes place. This can be determined by the Boltzman formula. The energy produced by the re-orientation of the ions increases the oscillation energy of the lattice, i.e. produces heat in the crystal. If the magnetic field changes its direction rapidly in

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comparison with t_o (where t_o is the time taken by the molecule to change its state), the upper level will contain more ions than the lower one. The deviation of the ion distribution from the equilibrium distribution will decrease in time, in accordance with:

$$\frac{d}{dt}\left[W(t) - W_{paBH}\right] = - \frac{W(t) - W_{paBH}}{T_1} \qquad (2)$$

where W is given by the next equation, N_i is the number of ions at the level having a spin i. Integration of Eq (2) results in Eq (3), where ΔN_{paBH} is the equilibrium value of ΔN in the field H; ΔN_o is the devition of ΔN at the time $t = 0$. From Eq (3), if follows that the system can be used to construct a molecular oscillator or amplifier (the author and

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Conversion of Mechanical Energy Into the UHF Energy in an UHF Motor

A.M. Prokhorov - Ref 4). The following amplifier is suggested. A paramagnetic sample having a disc shape rotates between the poles of two magnets whose fields H_1 and H_2 are opposite to each other (Figure 3). The sample is in thermal contact with a thermostat having a temperature T and the times during which the volume element dV of the sample finds itself in the fields H_1 and H_2 are τ_1 and τ_2, respectively. The deviations in the number of ions per unit volume of the sample can be determined from Eq (3); the deviations are therefore expressed by Eqs (4), where T_1 is the time of the spin-lattice relaxation. If $\tau_1 < T_1$ and $\tau_2 < T_1$, the ion deviations can be approximately expressed by Eqs (8). The situation is illustrated in Figure 4. The work done when the element of the sample is taken from the field H_1 into the field H_2 is given by Eq (9), where μ denotes the Bohr magneton. The energy which can be radiated by the

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ions into a resonator is given by :

$$W_{изл} = \left[\frac{\Delta N^{(1)}_{paBH}\, \tau_1}{2T_1} - \frac{\Delta N^{(2)}_{paBH}\, \tau_2}{2T_1} \right] h\nu_2 \qquad (11) .$$

The system of Figure 3 is irreversible. However, if H_1 and H_2 have the same direction, the system can become a source of mechanical energy and is capable of converting a part of high-frequency energy into mechanical energy. For this case, the mechanical energy can be expressed by Eq (14).

There are 6 figures and 5 references, of which 3 are English and 2 Soviet.

Card 4/5 4 Physics Inst im P.N. Lebeder, AS USSR

SOV/109-4-7-13/25

AUTHORS: Basov, N.G. and Orayevskiy, A.N.

TITLE: Absolute Stability of a Maser Oscillator Employing a Beam of Ammonia Molecules

PERIODICAL: Radiotekhnika i elektronika, 1959, Vol 4, Nr 7, pp 1185 - 1195 (USSR)

ABSTRACT: Maser oscillators have been described and analysed in a number of papers (Refs 1-9). In particular, an oscillator of this type can be constructed by employing two beams converging on each other; the system employs the inversion transition line of ammonia, $J = 3$, $K = 2$. In this oscillator, it should be possible to obtain absolute frequency stability of 10^{-10} or even 10^{-11}. In the following, it is shown that the same stability in a maser oscillator can be obtained by employing two coupled resonators; this was first realized by J. Bonanomi et al. (Refs 8,9). This method is more advantageous than the previous one since it does not require any special adjustment of the frequency during the operation of the oscillator. The frequency of the

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oscillations in a maser oscillator is given by:

$$\frac{\varepsilon' - 1}{\varepsilon''} = Q \frac{\omega}{\omega_o} \frac{\omega_o'^2 - \omega^2}{\omega_o^2} \approx 2Q \frac{\omega_o' - \omega}{\omega_o} \qquad (1)$$

where ε' and ε'' are the real and the imaginary parts of the complex permittivity of the molecular beam, respectively; Q is the quality factor of the resonator, ω_o is the natural frequency of the resonator and $\omega_o'^2 = \omega_o^2(1 + Q^{-2})$. Eq (1) can also be written as Eq (2), where $\langle\tau\rangle$ is the average transit time of the molecules in the resonator, while γ is given by the formula following Eq (2). Further, Eq (1) can be written as Eq (3), where Δ, Δ_1 and Q_L are defined by the last equations on p 1187. The functions $\varphi(\gamma)$ and $F(\theta)$ are dofined by the equations on p 1188. The components of the permittivity are expressed by Eqs (4). Eq (1) can therefore be written as Eq (6) where Δ is given by Eq (7). The oscillation frequency is therefore given by Eq (8), where ω_{mn} is the frequency of the molecular transition. The formulae can be used to evaluate the frequency deviation Δ as a function of the voltage α of the grouping system and the saturation parameter a. The results are plotted in Figure 1. It is seen that for the voltage change from 5 to 35 kV, the oscillation frequency changes by about 70 c.p.s. When the oscillator consists of 2 coupled resonators, its frequency deviation, with respect to the frequency of the molecular transition, is expressed by Eq (20). This can be rewritten and is then in the form of Eq (24), where Ω_1, Ω_o and Ω_{-1} are the roots of Eq (23). If the two resonators are tuned so that the three roots coincide with ω_{mn} with an error of a few percent of 1/Q, it is possible to

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Absolute Stability of a Maser Oscillator Employing a Beam of Ammonia Molecules

secure an absolute stability of the oscillator of the order of 10^{-11}. The design details of a two-resonator oscillator are indicated in Figure 3. There are 3 figures, 2 tables and 19 references, of which 8 are English, 2 German and 9 Soviet.

ASSOCIATION: Fizicheskiy institut im. P.N. Lebedeva AN SSSR (Physics Institute imeni P.N. Lebedev of the Ac.Sc., USSR)

SUBMITTED: February 18, 1958

Card 4/4

24(3)

AUTHORS: Basov, N. G., Vul, B. M., Popov, Yu. M. SOV/56-37-2-54/56

TITLE: Quantum-mechanical Semiconductor Generators and -Amplifiers of Electromagnetic Oscillations

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 37, Nr 2(8), pp 587-588 (USSR)

ABSTRACT: In the present "Letter to the Editor" the authors discuss the possibility of using the electron transitions between the conductivity zone (valence zone) and donor (acceptor) impurity levels of a semiconductor for the production of electromagnetic radiation (like in a molecular generator). For the realization of semiconductor generators and -amplifiers it is necessary to provide for such a distribution of electrons (holes) in the conductivity zone (valence zone) that the effective temperature of the conductivity electrons (holes) is negative with respect to the ionized donors (acceptors). Such a semiconductor has negative frequency losses in the case of transitions of electrons (holes) from the conductivity (valence) zone to impurity levels. If such a semiconductor is irradiated with electromagnetic waves, the latter may be amplified; if certain conditions (self-excitation)

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Quantum-mechanical Semiconductor Generators and Amplifiers of Electromagnetic Oscillations SOV/56-37-2-54/56

are satisfied, such a device may work as generator. In order to attain negative temperatures, a special impurity ionization mechanism is suggested. This state with negative temperature is maintained during the relaxation time of electrons (holes) with the impurity levels. If the number of impurities is small compared to the number of atoms in the crystal lattice, the life time of the conductivity electrons (holes of the valence zone) τ_2 is large compared to the time τ_1 between the collisions of electrons (holes) with the lattice. τ_2 may be regulated by the impurity concentration. During the period τ_2 the system may be used as a generator or as amplifier of electromagnetic oscillations. A reduction of the surface

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Quantum-mechanical Semiconductor Generators and Amplifiers of Electromagnetic Oscillations SOV/56-37-2-54/56

reflection coefficient or of the dimensions of the sample may convert the system from the function as generator to that of an amplifier. The present paper was registered by the Committee of Inventions and Discoveries of the USSR Council of Ministers with priority of July 7, 1958. There are 3 Soviet references.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk (Physics Institute imeni P. N. Lebedev of the Academy of Sciences)

SUBMITTED: May 18, 1959

Card 3/3

APPROVED FOR RELEASE: 06/06/2000 CIA-RDP86-00513R000203910013-2"

BASOV, N.G.; ORAYEVSKIY, A.N.

Use of slow molecules in molecular generators. Zhur.eksp.i teor.fiz. 37 no.4:1068-1071 O '59. (MIRA 13:5)
(Oscillators, Electric)

69738

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S/030/60/000/04/15/028
B022/B007

AUTHORS: Basov, N.G., Doctor of Physical and Mathematical Sciences, Prokhorov, A.M., Doctor of Physical and Mathematical Sciences

TITLE: Quantum Radio-physics - Authors' Lecture

PERIODICAL: Vestnik Akademii nauk SSSR, 1960, No. 4, pp. 110-119

TEXT: The practical application of quantum radio-physics for the generation and amplification of electromechanical waves was worked out at the Fizicheskiy institut im. P.N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P.N. Lebedev of the Academy of Sciences of the USSR), and the Institut radiotekhniki i elektroniki Akademii nauk SSSR (Institute of Radio-engineering and Electronics of the Academy of Sciences of the USSR). A quantum system with two energy levels is dealt with (Fig. 1). In interaction with an external electromagnetic field, this system is able to absorb and to emit energy quanta. Three processes developing here, viz. resonance absorption, induced emission, and spontaneous radiation, are mentioned, in which case equilibrium is established between the molecules and the quanta of the field. The scheme of a molecular

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Quantum Radio-physics - Authors' Lecture

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B022/B007

and characterized by an exceedingly high frequency stability. As working material a so-called cavity resonator frequently used in the range of centimeter waves, sorting system in form of a cylindrical condenser, and the oscillation circuit - consists of three main parts, namely the source of the molecule beam, the ture is shown in Fig. 2 and the generator itself in Fig. 3. The generator generator for the emission of a beam of ammonia molecules with negative tempera-

crystals are used in molecular amplifiers, which contain paramagnetic ions, which was first suggested by Ye.K. Zavoyskiy. The scheme of such an amplifier is shown in Fig. 4. For the purpose of obtaining a negative temperature in the paramagnetic crystals, an auxiliary radiation is used (Fig. 5). The paramagnetic amplifiers are able to work at the temperature of liquid helium ($T = 4.2^{\circ}K$). The possibility is, however, pointed out of using parameter amplifiers. A paramagnetic amplifier without magnet and cryostat is shown in Fig. 6. Methods of obtaining negative temperatures in semiconductor systems are developed, investigations are carried out in the region of submillimeter waves, and experiments with respect to the increase in the sensitivity of receivers are made, in which molecular amplifiers were used. There are 6 figures.

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E140/E435

AUTHORS: Basov, N.G. and Karlov, N.V.

TITLE: Brief Communication on a Wideband Radiometer with Quantum Spectrum Converter

PERIODICAL: Radiotekhnika i elektronika, 1960, Vol 5, Nr 4, pp 676-677 (USSR)

ABSTRACT: The use of a molecular system with three discrete energy levels is proposed for converting a wideband radiation to monochromatic oscillation. This system may be used to receive signals at higher frequencies than the auxiliary oscillation. A.Ye.Salomonovich participated in discussion of the work. There are 2 figures.

ASSOCIATION: Fizicheskiy institut im. P.N.Lebeveva AN SSSR (Physics Institute imeni P.N.Lebedev, AS USSR)

SUBMITTED: December 23, 1958

Card 1/1

82430

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S/056/60/038/03/31/033
B006/B014

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: Semiconductor Amplifiers and Generators Whose Carriers Have a Negative Effective Mass

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 38, No. 3, pp. 1001-1002

TEXT: Kroemer (Ref. 1) made the suggestion to use carriers with a negative effective mass in semiconductors for the amplification and generation of electromagnetic waves, since negative losses will thus occur during the motion of carriers in the field. In order to produce such states it is advisable to use a constant electric field. In the present "Letter to the Editor" the authors demonstrate that it is impossible to produce states with negative losses by using a constant electric field. The condition $wf(\varepsilon_2)[1-f(\varepsilon_1)]n(\hbar\omega)-wf(\varepsilon_1)[1-f(\varepsilon_2)]n(\hbar\omega)= = wn(\hbar\omega)\{f(\varepsilon_2)-f(\varepsilon_1)\} > 0$ must be satisfied for the energies $\varepsilon_2 > \varepsilon_1$ ($f(\varepsilon)$ is the electron distribution function, $n(\hbar\omega)$ is the number of

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Semiconductor Amplifiers and Generators Whose Carriers Have a Negative Effective Mass

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photons of an energy $\hbar\omega = \varepsilon_2 - \varepsilon_1$, w is the probability of spontaneous emission). To obtain amplification, it was necessary that $\partial f(\varepsilon)/\partial\varepsilon > 0$, at least at some points of the range $\varepsilon_2 - \varepsilon_1$. This is nowhere the case if thermodynamic equilibrium is to be maintained. Direct calculations (Refs. 2-5) have shown that it is impossible to disturb thermodynamic equilibrium so strongly that $\partial f(\varepsilon)/\partial\varepsilon > 0$, if E = const, as was assumed by Kroemer. Also if in the case of anisotropic zones some components of the mass tensor are negative for certain values of the quasi-pulse, $\partial f/\partial\varepsilon > 0$ cannot be attained if E = const. This is due to the fact that in the case of semiconductors the interaction constant for acoustical and optical phonons is of the same order of magnitude. For a system of semiconductors with negative losses it is therefore necessary to obtain states with negative temperatures if $\partial f/\partial\varepsilon > 0$. There are 6 references, 3 of which are Soviet.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences, USSR)

Card 2/3

86932

S/056/60/039/005/051/051
B006/B077

24.7700 (1043,1143,1559)

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: The Possibility of an Application of Indirect Transitions to Produce Negative Temperature in Semiconductors.

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 5(11), pp. 1486 - 1487

TEXT: In some semiconductors, especially in germanium and silicon, the infrared emission and absorption edges correspond to the indirect transitions, that is during emission and absorption of a photon emission or absorption of a phonon takes place simultaneously. The long wave emission corresponds to simultaneous emission of photon+phonon on these transitions. In a sample with a low enough temperature where the phonons necessary for absorption are missing in the lattice, the emission with the longest wave will not be absorbed and here the sample will be practically transparent. If the carrier concentration is increased with

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The Possibility of an Application of Indirect Transitions to Produce Negative Temperature in Semiconductors.

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respect to the equilibrial concentration by means of any mechanism (exposure, electric field etc.) then under certain conditions a negative temperature should occur with respect to the considered transitions. The conditions for such a process should be: $\omega_r/\omega_f < T_{eff}/T$, where ω_r and ω_f is the photon and phonon frequency, T the temperature of the sample and T_{eff} the effective temperature where the levels of the conduction band with respect to those of the valence band are filled. For germanium would hold $\omega_r/\omega_f \sim 25$ and thus $T_{eff}/T > 25$, which would be fulfilled for a sample at helium temperature if the excitation is brought about by a radiation source or an external electric field. There are 10 references: 1 Soviet, 8 US, 1 Czechoslovakian.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR)

SUBMITTED: October 3, 1960

Card 2/2

88459

24.2120 (1155,1482) also 2114

S/056/60/039/006/051/063
B006/B063

AUTHORS: Basov, N. G., Krokhin, O. N.

TITLE: Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 6(12), pp. 1777-1780

TEXT: A study has been made of the conditions, under which negative temperatures may occur in a gas discharge of a binary gas mixture, in which the atoms have the same energy levels. Experimental and theoretical publications by Sanders, Javan, S. G. Rautian, I. I. Sobel'man, A. Ferkhman, S. Frish, V. K. Ablekov, M. S. Pesin, and I. L. Fabelinskiy are discussed in the introduction. Javan has shown that in a binary gas mixture, in which two energy levels of different atoms are very close to each other, excitation may pass from an atom of one gas to an atom of the other. This has a great influence on the distribution of excited states among the atoms. Following the results obtained by Javan, the authors have studied the case where the energy levels coincide, on the assumption that

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Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

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$T_e \gg T_a$. If the lifetime of an excited state were only dependent on collisions of second kind between electrons and atoms, the number of excited atoms would be given by $N_i = N_o \exp(-\varepsilon_i/kT_e)$, where ε_i is the excitation energy; N_o is the number of atoms in the ground state; and T_e is the electron temperature. On account of the conversion of excitation energy into kinetic energy and due to radiation processes, N_i is actually much smaller. This fact is considered by referring the temperature only to two levels $\varepsilon_i^a = \varepsilon_i^b$ of the atoms of the gases a and b. For such levels it may be assumed that the interaction cross section for the atoms has a resonance character. Consequently, the excitation transfer between atoms a and b is considerable. Such an interaction between ε_i^a and ε_i^b can lead to a leveling of temperature. If, for example, T_i^a is first greater than T_i^b, ε_i^a will be excited with a temperature $T_i^{a'} > T_i^a$, and a negative temperature is likely to occur between the level ε_i^a and a level $\varepsilon_k^a < \varepsilon_i^a$, whose temperature

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Conditions for Electron Excitation of Negative Temperature States in a Gas Mixture

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B006/B063

$T_k^a < (\varepsilon_i^a/\varepsilon_k^a)T_i^{a'}$. Several relations are derived for some details of these conditions. There are 1 figure and 6 references: 4 Soviet and 2 US.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR)

SUBMITTED: July 22, 1960

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6.3200 (2503, 2803)
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85900
S/053/60/072/002/001/005
B006/B067

AUTHORS: Basov, N. G., Krokhin, O. N., and Popov, Yu. M.

TITLE: Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

PERIODICAL: Uspekhi fizicheskikh nauk, 1960, Vol. 72, No. 2, pp. 161 - 209

TEXT: The present paper gives comprehensive survey of the theory, the possibilities of application, and the properties of molecular generators and intensifiers. In the introduction the authors discuss the sources of electromagnetic radiation which they divide into three groups (thermal source, luminescence source, and generators) and which differ above all by the width of the emission spectrum. They then discuss the principle of the generation and intensification of waves which is based on the induction of transitions in quantum systems (molecules, atoms, ions, etc.). Molecular generators, and paramagnetic intensifiers may be used for the generation and

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intensification of submillimeter infrared and optical waves. To produce such generators and intensifiers it is necessary to obtain a system which is not in thermodynamic equilibrium (i.e. in a state with negative temperature). In such a state the occupation of the energy levels is bound to increase with increasing energy, and the system is bound to emit photons under the influence of a radiation impinging from outside. It may be used not only for the generation but also for the intensification of radiation. In spite of the spontaneous radiation such intensifiers are considerably sensitive in the infrared. It has already been suggested to use spectral lines of different materials for producing highly sensitive radiation indicators which are free from noises of spontaneous radiation. One of the most important characteristics of such a system with negative temperature is the "number of active particles", i.e., the particle excess on the upper levels compared with the lower ones which are generated per unit time. Another important characteristics is the quantity $\varkappa = 2\pi|d|^2 n/\hbar\Delta\omega$, where $|d|^2$ is the square of the matrix element

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Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

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of the dipole moment between the levels concerned, n the number of the active particles, and $\Delta\omega$ the spectral line width. The quantity κ enters the condition of the self-excitation of the generators and determines the intensification coefficient of the intensifier, as is shown in part 8. In molecular gases K is in the cm range only $1/10^3$ of the value it has in crystals of paramagnetic ions. Similar conditions prevail also in the infrared. Hence the use of solids seems to be the most promising. The present paper which gives a survey of published data and the results obtained in this field is presented in the following way: Chapter I: methods of obtaining states in systems with negative temperatures. The theory of negative temperatures; sorting of molecules by means of an inhomogeneous electric or magnetic field in molecular beams; the excitation of gas molecules by means of gas discharge; momentum method of producing negative temperatures in semiconductors; production of negative temperatures in semiconductors between levels lying within one conduction band ("amplifier with negative mass"); production of negative temperatures by the method

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Generation, Intensification, and Detection of Infrared and Optical Radiation by Means of Quantum Systems

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of double resonance. Chapter II: Interaction between radiation and systems with negative temperature; conditions of self-excitation; theory and suggestions for the production of resonators and intensifiers; quantum indicators of radiation. Finally, it is pointed out that quantum systems are of great importance in the generation and intensification of electromagnetic cm and dm waves, especially for radio engineering. Increase in the frequency stability and considerable increase in the receiver sensitivity. With ammonia molecular generators already high frequency stability was attained. The noise temperature in this region is at about $10^{\circ}K$. Research in this field leads to a new branch of physics: quantum radiophysics. V. A. Fabrikant is mentioned. There are 23 figures and 80 references: 33 Soviet, 34 US, 3 Japanese, 7 Australian, 2 British, and 1 French.

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BASOV, N.G.; KROKHIN, O.N.; POPOV, Yu.M.

Generation, intensification, and indication of infrared and optical radiation with the aid of quantum systems. Usp. fiz. nauk 77 no.2:161-209 O '60. (MIRA 16:8)
(Radiation) (Quantum theory)

BASOV, N. G., KROKHIN, O. N. and POPOV, Yu. M.

"Negative Absorption Coefficient at Indirect Transitions in Semiconductors."

report presented by N. G. Basov at the 2nd Intl. Conference on Quantum Electronics, 23-24 Mar 1961, Berkeley, California.

BASOV, Nikolay G. (USSR) Physics Institute imeni P. N. Lebedev, Moscow.

"Formation of Negative Temperatures in Gaseous Mixtures". (Session IV).

Report to be submitted for the 2nd Intl. Conference Quantum Electronics, Berkeley, California, 23-25 Mar 61.

~~BASOV, N. G., OSIPOV, B. D. and CHVJUCHEV~~

"Recombination Radiation in InSb ."

report presented at the Hungarian Symposium on Luminescence, Balatonvilagos, Hungary, 7-10 June 1961.

BASOV, N. G., POPOV, Yu. M. and KROKHIN, O. N.

"Negative Absorption Coefficient at Indirect Transitions in Semiconductors."

report presented at the Hungarian Sumposium on Luminescence, Balatonvilagos, Hungary, 7-10 June 1961.

RYTOV, Sergey Mikhaylovich, prof., doktor fiziko-matem.nauk; MILLER, Vladimir Viktorovich, kand.fiziko-matem.nauk; BASOV, Nikolay Gennadiyevich, prof., doktor fiziko-matem.nauk; PROKHOROV, Aleksandr Mikhaylovich, prof., doktor fiziko-matem. nauk, laureat Leninskoy premii; FAYNBOYM, I.B., red.; ATROSHCHENKO, L.Ye., tekhn.red.

[New problems in physics] Novye problemy fiziki; sbornik statei. Moskva, Izd-vo "Znanie," 1961. 44 p. (Vsesoiuznoe obshchestvo po rasprostraneniiu politicheskikh i nauchnykh znanii. Ser.9, Fizika i khimiia, no.7) (MIRA 14:6)
(Astronautics) (Relativity)

BASOV, N. G., KROKHIN, O. N., LISITZYIN, L. M., MARKIN, E. P., OSIPOV, B. D.

"On Negative Photoconductivity and the Induced Electron Transitions"

Paper presented at the IUPAP International Conference on Photoconductivity, Ithaca, New York, 21-24 Aug. 1961.

P. N. Lebedev Institute of Physics, Academy of Sciences, USSR.

20699

9.2574 (also 1163)

S/120/61/000/001/037/062
E032/E114

AUTHORS: Basov, N.G., and Zuyev, V.S.

TITLE: A Maser Using an ND_3 Molecular Beam

PERIODICAL: Pribory i tekhnika eksperimenta, 1961, No.1, pp.120-121

TEXT: A molecular beam maser has been built and is in operation at the Fizicheskiy Institut AN SSSR (Physics Institute, AS USSR). The maser is shown in the figure and uses the inversion transition J = 6, K = 6 at 1656.18 Mc/s (Ref.2). The design of the maser is similar to the NH_3 maser described by J.P. Gordon et al. in Ref.5. A particular feature of the present device is that, in order to obtain a sufficient number of "active" molecules, large fields have to be used for which the Stark effect becomes linear, since the intensity of the transition is considerably lower than that for NH_3. In the figure 1 is the beam source, 2 is the separating system and 3 is the resonator. The diameter of the rings in the separating system is 4 cm and the distance between the rings is 2 cm. Altogether 22 rings are employed, the total length of the system being about 50 cm. A narrow beam is produced with the aid of the liquid nitrogen

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E032/E114

A Maser Using an ND_3 Molecular Beam

cooled diaphragms 4 and 5. The diameter of the latter is equal to the diameter of the rings. The signal is detected by a superheterodyne receiver; the signal-to-noise ratio was found to reach 100. The design of the separating system has been discussed by V.A. Shcheglov in Ref.7. The cylindrical resonator TM 010 (TM_{010}) has a diameter of 13.8 cm and is 40 cm long. Its Q factor is 20 000. Freezing out of the unnecessary gas is achieved with the aid of the liquid nitrogen cooled surface 6. Self-excitation was observed at 80 kV with the pressure in the beam source at about 0.1 mm Hg. At 110 kV, and the same beam source pressure, the power was about 10^{-11} W.
There are 1 figure and 7 references: 5 Soviet and 2 English.

ASSOCIATION: Fizicheskiy institut AN SSSR (Physics Institute, AS USSR)

SUBMITTED: February 12, 1960

Card 2/2

S/029/61/000/009/001/006
D037/D113

AUTHOR: Basov, N.G., Professor, Lenin prize winner

TITLE: Radiocommunication with the nearest stars is practicable

PERIODICAL: Tekhnika molodezhi, no. 9, 1961, 5

TEXT: The article deals with the generation and possible application of light waves for communication and computing purposes. Current uses of quanta generators and receivers are cited. Quanta generators are used in the manufacture of super-precision clocks, for checking theoretical deductions, for guiding aircraft and ships, and for measuring large distances. Quanta receivers are used for increasing the sensitivity of receiving apparatus and the effective range of radiotelescopes and radiolocators. It is stated that, by using masers, radio contact can be made with the stars nearest the earth. By using the radio waves of the visible waveband, a projector 20-30 cm in diameter could illuminate a part of the moon 1 km^2 in diameter, one transmitter could simultaneously transmit 10,000 TV programs,

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Radiocommunication S/029/61/000/009/001/006
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and high-speed computers, capable of performing many thousand billions of operations per second, could be built. An extremely powerful probe can be produced by the very sharp focussing of the radioradiation of quanta generators. Charged particle accelerators thus produced can be used for processing various materials, for experimentally checking problems of quanta electrodynamics, and for studying thermonuclear processes.

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BASOV, N., doktor fiziko-matem.nauk

Solid state devices in radio electronics. Radio no.10:6 0 '61.
(MIRA 14:10)

1. Zamestitel' direktora Fizicheskogo instituta im. P.I.Lebedeva.
(Radio)

29241 S/026/61/000/012/002/003
9.2574 (also 1158, 1055) D037/D113

AUTHORS: Basov, N.G., Krokhin, O.N., and Popov, Yu.M.

TITLE: Generators and amplifiers of light

PERIODICAL: Priroda, no. 12, 1961, 16-25

TEXT: This article deals with the development of quantum radiophysics and the theory, development and application of generators of monochromatic, optical and infrared radiation. In 1952, a new principle of generating and amplifying electromagnetic radiation in quanta systems, based on induced radiation, was proposed by N.G. Basov and A.M. Prokhorov. In 1954-55, the first quantum generators of the electromagnetic waves of the centimeter band, based on induced radiation, were built. Quantum amplifiers of the centimeter and decimeter wavebands, used for increasing the sensitivity of receiving equipment and proposed for the first time in 1956 by N. Blumbergen, are based on the 3-level system studied by N.G. Basov and A.M. Prokhorov. Optical generators, based on the same principles, were proposed for the first time in the USSR in 1957-58 by Basov, Prokhorov, B.M. Vul and Yu.M. Popov. It is stated that world-wide attempts are being made to use quantum systems X
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29241 S/026/61/000/012/002/003
D037/D113

Generators and amplifiers of light

for the creation and development of generators and amplifiers in the meter and ultraviolet wavebands and possibly also in shorter wavebands. The authors give a very general explanation of resonance absorption, induced and spontaneous radiation, and quanta systems working with "negative temperature". They point out the need to develop devices ensuring the possibility of obtaining monochromatic radiation with the aid of media of finite dimensions, suggesting in this connection the use of a system of parallel mirrors. In radiowave generators, the parallel mirrors are replaced by a resonator which can concentrate all radiation energy on one type of oscillation, thus ensuring high-directivity radiation and monochromatization. Discussing generators of optical and infrared radiation, the authors describe two types of generators, one of them using a mixture of helium (pressure 1 mm Hg) and neon (0.1 mm Hg) excited by low-temperature discharge and enclosed in a quartz envelope. In the second type, spectral radiation lines of various solids, mainly monocrystals excited by intensive optical radiation, are used. The monocrystal of a synthetic ruby has latterly been replaced by uranium and samarium ions in calcium fluorite. Semiconductors, used instead of luminescent crystals in optical and infrared radiation generators, also give very good results: accomplishment of electrical excitation methods, high density X
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D037/D113

Generators and amplifiers of light

of the excited centers, and the possibility of changing the generation rate in the magnetic field. In the high light concentrations of optical waveband generators, the light pressure may be up to 1 million at. and may be used for studying the properties of substances on strong electrical fields, acceleration of charged particles, acceleration of chemical reactions and exact processing of various materials. Soviet scientist V.A. Fabrikant is mentioned in connection with research work in this field. There are 8 figures and 2 Soviet-bloc references.

ASSOCATION: Fizicheskiy institut im. P.N. Lebedeva AN SSSR(Moskva)
(Physics Institute im. P.N. Lebedev of the AS USSR[Moscow])

X

Card 3/3

22266
S/109/61/006/005/013/027
D201/D303

9.2582 (1055, 1163)

AUTHORS: Basov, N.G., Nikitin, V.V., and Orayevskiy, A.N.

TITLE: Investigation into the dependence of the frequency of molecular generators on various parameters. Part I (Theory, line J = 3, K = 2)

PERIODICAL: Radiotekhnika i elektronika, v. 6, n. 5, 1961, 796-805

TEXT: The work presented in this article was undertaken in order to explore the possibility of utilizing a molecular generator as an absolute frequency standard having an accuracy of about 10^{-10}. In order to determine the type of construction required and its operation, a detailed account of how its frequency depends on the various parameters has been undertaken. Several attempts to evaluate the influence of various factors in the oscillation frequency have been made by N.G. Basov, and A.M. Prokhorov (Ref. 1: Uspekhi fiz.

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nauk 1955, 1, 7, 485) and by K. Shimoda, T.C. Wang and C.H. Townes (Ref. 2: Phys. Rev. 1956, 5, 102, 5, 1308), the dependence of the frequency of the molecular generator on the resonant frequency of the resonator being explained in Ref. 2 (Op.cit.). It was shown that the irregularities of beam emission along the resonator introduce frequency drift: The influence of the non-resolved components of the hyperfine structure was shown by K. Shimoda (Ref. 3: J. Phys. Soc. Japan 1957, 12, 1006; 1958, 13, 939); the dependence of the frequency drift of the molecular generator based on the hyperfine structure on the voltage of the sorter and on the beam intensity has been explained by N.G. Basov and A.N. Orayevskiy (Ref. 4: Radiotekhnika i elektronika, 1959, 4, 7, 1185). The results discussed cannot be taken, however, as final since none of the authors take into account the real velocity spread of molecules. First the influence of various parameters, including the velocity spread of molecules has been analyzed. Starting with

$$\frac{\overline{\varkappa}'}{\overline{\varkappa}''} = 2Q\,\frac{\omega_0 - \omega}{\omega}, \qquad (1)$$

given in Ref. 1 (Op.cit.) for the oscillations frequency of a molecular generator where

$$\overline{\varkappa} = \overline{\varkappa}' + i\overline{\varkappa}''$$

is the average complex polarization of the molecular beam, ω - is the required frequency, ω_0 - the self resonant frequency of the resonator having the quality factor Q, it is shown that this equation provided $\varkappa$ is properly evaluated, must take into account all factors affecting the frequency and its stability. These, state the authors, are listed in Ref. 4 (Op.cit.). After several mathematical transformations and assumptions, the Eq. (1) for two levels is derived as

$$\omega = \omega_1 \left[1 + \frac{\omega_0 - \omega_1}{\omega_1} \frac{Q}{Q_1} G + \triangle \right] \qquad (6)$$

where

$$G = \frac{\sum_m |d_m|^2 \gamma_m^{-1} J_m^c}{\sum_m |d_m|^2 \gamma_m^{-2} J_m^s}; \quad \Delta = \frac{\sum_m \eta_m |d_m|^2 \gamma_m^{-1} J_m^s}{\sum_m |d_m|^2 \gamma_m^{-1} J_m^s}. \qquad (7)$$

and ω_1 is such that $\omega_m = \omega_1 + \eta_m$; ω_m - frequency of the molecular transition; d_m - matrix element of the dipole moment $d_m = d_o \lambda_m$ where d_o - the dipole moment, λ_m determines d_m on quanta numbers characterizing the given transition;

$$\gamma_m = \gamma \frac{\lambda_m^2}{\bar{\theta}^2}; \quad \gamma = \frac{d\mathcal{E}}{\hbar} \bar{\theta};$$

$\mathcal{E}$ - the field amplitude in the resonator; $\bar{\theta}$ - the average transient time of molecules through the resonator. J_m^s and J_m^c are given by

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$$J_m^s = \int_0^\infty F(\theta)\left(1 - \frac{\sin \gamma_m \theta}{\gamma_m \theta}\right) d\theta,$$

$$J_m^c = \int_0^\infty F(\theta) \frac{1 - \cos \gamma_m \theta}{\gamma_m \theta} d\theta \quad (5)$$

where $F(\theta)$ - time distribution of molecules in resonator. Functions G and Δ have been evaluated using an electronic computer and are represented graphically for the spectral line of ammonia $N^{14}H_3$ J = 3, K = 3. The rest of the theoretical results are based on N.G. Basov, G.M. Strakhovskiy, and I.V. Cheremiskin (Ref. 5: Radiotekhnika i elektronika 1961, 6, 6) and given as graphs. Fig. 3 shows the dependence of frequency on the pressure p in the molecular beam source with factor 3 compensated for line J = 3, K = 3, $N^{14}H_3$. The pressure p is given in relative units. Fig. 4 shows the dependence of frequency on the voltage at the sorter. Effect No. 3 is compensated for the line J = 3 , K = 3 $N^{14}H_3$. Fig. 5 is the same as Fig. 4 but apparently for J = 3, K = 2 $N^{14}H_3$ /Abstractor's note: This would seem to be an error. The graph shows the detuning Δf as function of pressure p in the source/. The experimental verification of the theoretical results was carried out on a molecular generator using the line of the inversion transition of ammonia $N^{14}H_3$ J = 3, K = 2 which has no quadruples of the hyperfine structure. Three exactly similar generators were used each having two molecular beams running in opposition. The schematic diagram of the generator is shown in Fig. 7. In it a - sources of molecular beams; 1 - quadruple condensors, c - resonator; d - diaphragms cooled by liquid nitrogen. The resonator was made of invar, excited in E_{010} mode, the length of the resonator was 11.2 cm which corresponded to the transit width of the line of 1 Kc/s, q - 9000, timed within a few megacycles. Sorting of molecules according to their energy levels was achieved using quadruple condensers having a length of 15 cm. A diaphragm was used to increase the beam intensity. The aperture of the diaphragm was 0.6 cm. The diaphragm was cooled by liquid nitrogen the molecule beam was obtained by a grid having square holes 0.05 · 0.05 mm^2, spaced 0.05 mm from each other. The signal from two molecular generators was applied to a balanced mixer of a superheterodyne receiver, the local oscillator of which was stabilized by a cavity resonator. The IF was 60 Mc/s, the pass band of the IF amplifier 2 Mc/s. At the output, the difference frequency of the two generators determined from a Lissagian figure was compared with the frequency of an audio generator which in turn, by using a crystal controlled generator could have the frequency adjusted and measured with an accuracy of 0.1 to 1 c/s. The pressure within the source was measured by a pressure tube ЛТ-2 (LT-2). The overall tuning accuracy of the molecular generator achieved by adjustments of its various parameters was around 3c/s. The experimental results are given in the form of graphs. It is stated in conclusion that a molecular generator, having two similar and opposite beams working at a line without a hyperfine structure and having a symmetrical construction, can be used as an absolute standard of frequency time with an accuracy of 10-10. There are 10 figures and 6 references: 3 Soviet-bloc and 3 non-Soviet-bloc. The references to the English-language publications read as follows: K. Shimoda, T.C. Wang, C.H. Townes, Phys. Rev. 1956, 5, 102, 5, 1308 K. Shimoda, J. Phys. Soc. Japan 1957, 12, 1006: 1958, 13, 939; J.P. Gordon, Phys. Rev. 1955, 994, 1253.

ASSOCIATION: Fizicheskiy institut im P.N. Lebedeva AN SSSR (Institute of Physics im. P.N. Lebedev, AS USSR)

SUBMITTED: June 17, 1960

24473

9,2582

S/109/61/006/006/014/016
D204/D303

AUTHORS: Basov, N.G., Strakhovskiy, G.M., Cheremiskin, I.V.

TITLE: A study of dependence of molecular generator frequencies on various parameters. Part II. Line J=3, K=3

PERIODICAL: Radiotekhnika i elektronika, v. 6, no. 6, 1961, 1020 - 1028

TEXT: Following the theoretical analysis as given by N.G. Basov, A.V. Nikitin, and A.N. Orayevskiy (Ref. 5: Radiotekhnika i elektronika 1961, 6, 5, 796); the authors give in the present article the results of the experimental study of a molecular generator J=3 K=3 of ammonia $N^{14}H_3$. Its frequency was studied as dependent on the tuning of the resonator, on the voltage at the quadruple capacitor and pressure at the molecular beam source. The source, capacitor and resonator were very accurately designed. The beam was shaped by a 0.05 x 0.05 mm grid with the space factor of 0.25, thickness of the grid 0.05 mm. The diameter of the output beam -

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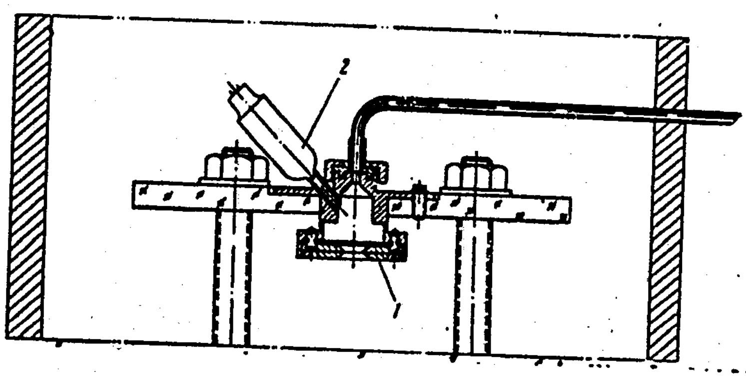
6 mm. Gas pressure inside the source was measured by a vacuum gauge BT-2 (VT-2). The pressure gauge tube ЛТ-4 (LT-4) was connected directly to the source camera (Fig. 2).

Fig. 2. Source of molecular beam 1 and pressure gauge tube 2.



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A study of dependence of ... S/109/61/006/006/014/016 D204/D303

A diaphragm forming a very narrow molecule beam was inserted between the source and quadruple condenser. The diaphragm was liquid nitrogen cooled. The capacitor was 150 mm long with spacing between plates of 2 mm. The beam was entered into a resonator 80 mm, with E_{olo} made of oscillatrons. The invar resonator had silvered walls, its Q 6000-8000. Tuning of the resonator within a few megacycles was achieved by a 2 mm diameter rod, screwed into the resonator to a depth up to 1 mm. The Q was not affected by tuning. The displacement of tuning rod by 0.1 mm (10 divisions on the Vernier) changed the resonant frequency of the resonator by approximately 0.5 mc/s and the generated frequency by approximately 1000 c/s. The resonant cavity was thermostatically controlled within 0.01°C, this change in temperature producing a frequency change of the generator of 1 c/s. The frequency changes in the generator due to changing its parameters were measured by comparing it with another generator, the frequency of which was kept constant within 2-5 c/s. The frequencies of three molecular generators differing

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A study of dependence of ... S/109/61/006/006/014/016
D204/D303

by a few hundred cycles, were mixed in a hybrid ring, actually a balanced mixer, to which was also applied the output of a heterodyning klystron 5, tuned to 23,830 Mc/s. From the balanced mixer the generated power was applied to F, a 40 Mc/s IF amplifier with a 2 Mc/s passband and gain of 10,000. The klystron local oscillator was frequently stabilized to approximately 50 kc/s. After the second detector, the signal having a frequency Δf between the difference of frequencies of molecular generators No. 3 and No. 2 was applied to an oscillosope type Эо-7 (Eo-7) with the output of an audio generator ЗГ-12 (ZG-12) applied to the horizontal sweep terminals and Δf was measured from the Lissajous figures, the relative power change was measured simultaneously with Δf by means of deflecting part of the power from the resonator and by amplifying it in a narrow band IF amplifier (pass-band about 70 Kc/s), with double frequency conversion. Using the above method three series of graphs were taken. 1) Changes in amplitude (power) W and in generated frequency Δf as dependent on changes in pressure p at the source, for various fixed detunings v of resonator and various U

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at the condenser. $W = f(p)_{\nu,u}$; $\Delta f = f(p)_{\nu,u}$; 2) Changes in amplitude (power) and in the frequency of the generator as dependent on the voltage for different fixed pressures and detuning of the resonator: $W = f(u)_{p,\nu}$; $\Delta f = f(U)_{p,\nu}$; 3) Changes in amplitude (power) and of the generated frequency with changes in resonator tuning: $W = f(v)_{p,u}$; $\Delta f = f(v)_{p,U}$ for given pressure and voltage at the capacitor. The generation of frequency was observed in the absence of voltage at the quadruple capacitor. It was also observed that even with the icing and subsequent partial blocking of the diaphragm, the generators continued to operate. The analysis of experimental graphs illustrating the dependence of generated frequency on parameters of the molecular generator, permits evaluation of the maximum possible long term relative stability of oscillations for the line J=3, K=3. Assuming the pressure in the source to be static within 1 % the voltage at the capacitor within 0.2 % and the temperature of the cavity resonator left within

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A study of dependence of ... 24473 S/109/61/006/006/014/016 D204/D303

0.002°C the long term relative stability

$$\frac{\Delta f}{f} \cong 10^{-11}.$$

It is also seen that tuning by pressure and voltage change does not seem to be very accurate since it would require too accurate changes in these quantities and, for the analyzed type of generator, tuning thus obtained could not be better than LO-8. Finally, to increase the absolute stability of the generator, lines of ammonia without hypertone structure should be used, e.g. J=3, K=2 $N^{14}H_3$ or lines $N^{15}H_3$. There are 10 figures and 8 references: 3 Soviet-bloc and 5 non-Soviet-bloc. The four most recent English-language publications read as follows: J.C. Helmer, J. Appl. Phys. 1957, 28, 212; K. Shimoda, J. Phys. Soc. Japan, 1957, 12, 1006; K. Shimoda, J. Phys. Soc. Japan, 1958, 13, 939; F. Barnes, Proc. I.R.E., 1959, 47, 2085.

SUBMITTED: June 17, 1960

Card 6/6

BASOV, N.G., doktor fiziko-matematicheskikh nauk

On the way to optical radio. Nauka i zhizn' 28 no.7:34-35 Jl '61.
(MIRA 14:8)

1. Zamestitel' direktora Fizicheskogo instituta imeni P.N. Lebedeva, AN SSSR.

(Electron optics)

BASOV, N.G., prof., laureat Leninskoy premii

Radio communications with the nearest stars is a realistic project. Tekh.mol. 29 no.9:5 '61.
(Radio waves) (Quantum mechanics) (MIRA 14:10)

6,3300 (incl. 2605)
6,3000 (2105, 1106, 1138)

21319
S/030/61/000/003/004/013
B105/B215

AUTHORS: Basov, N.G., Krokhin, O.N., Popov, Yu.M.

TITLE: Generation of coherent light by means of solids

PERIODICAL: Vestnik Akademii nauk SSSR, 31, no. 3, 1961, 61 - 66

TEXT: A short survey is given on methods of producing generators for optical and infrared radiations, in which quantum transitions among energy levels in solids, luminophores, and semiconductors are utilized. Infrared and optical generators are mentioned which are based upon the principle of induced radiation in quantum systems of negative temperatures (N.G. Basov, A.M. Prokhorov, 1954), highly coherent radiation sources of luminescent substances in infrared and optical spectral regions, exciting by strong optical radiation (T.G. Mayman, D.F. Nel'son, A.L. Shavlov, P.P. Sorokin, 1960). The production of such sources is closely related to the problems of interaction between radiation and substance, structures of the energy levels of the substances, probability of radiation and nonradiation processes. S.I. Vavilov contributed considerably to the solution of these problems. The action of permanent afterglow of organic luminophores which

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have been discovered by S.I. Vavilov and V.L. Levshin (1928) possibly is used for creating new sources of light. P.P. Feofilov (student of S.I. Vavilov) together with L.N. Galkin studied (1957) in detail absorption bands and emission of U^{+++} in calcium fluorite. Resonators are used to increase the interaction between radiation and substance of negative temperature (A.M. Prokhorov, 1958; A.L. Shavlov, 1958). Furthermore, a report is given on the generation of optical and infrared radiation by applying activators in corundum and calcium fluorite. The optical radiation source used was a corundum crystal (Al_2O_3) with of Cr_2O_3 impurities (0.05 per cent by weight). The wide absorption band of the transition level $^4A_2$ to $^4F_2$ corresponds to a wavelength of $\sim$5600 Å. Fig. 2 shows a schematic representation of the uranium ion level in the calcium fluorite crystal. Some methods of creating negative temperatures in semiconductors are recommended (N.G. Basov, B.M. Vul and Yu.M. Popov, 1958) for generating infrared and optical radiations by semiconductors. Negative temperatures of semiconductors can be reached by intrazonal electron-hole transitions, and by intrazonal transitions and transitions from the base region to the level of impurity atoms. So far, there exists no general theory on the determination of the lifetime of nonequilibrium carriers in semiconductors. The difficulties arising in connection with high a high excitation energy, disappear when indirect transitions in germanium and silicon semiconductors are utilized (N.G. Basov, O.N. Krokhin, and Yu.M. Popov, 1960). The minimum energy in the conduction band of these semiconductors, and the maximum energy in the valence band correspond to different values of the quasi-momentum of the electron (Fig. 4). The longest long-wave radiations correspond to the transition of the electron from the minimum conduction band into the maximum valence band; and at the same time a phonon is emitted so that the sum of the energies of photon and phonon equals Δ. The width of the spontaneous radiation line in semiconductors equals kT. In semiconductors, a change in frequency by superposition of a magnetic field of $\sim 1.5 \cdot 10^{-20} \frac{H}{m}$ is possible due to the low effective carrier mass m. For germanium it is 10% of the radiation frequency of intrazonal transitions in fields of $H \sim 10^4$ Gauss. Probably it will soon be possible to develop generators of infrared and optical radiation which can be used in laboratories, and also in various fields of science and technology. There are 4 figures.

BASOV, N.G.; KROKHIN, O.N.; POPOV, Yu.M.

Using indirect transitions in semiconductors for determining states with negative absorption coefficients. Zhur. eksp. i teor. fiz. 40 no.4:1203-1209 Ap '61. (MIRA 14:7)

1. Fizicheskiy institut imeni P.N.Lebedeva AN SSSR.
(Semiconductors) (Quantum mechanics)

9.4300

25208

S/056/61/040/006/029/031
B125/B202

AUTHORS: Basov, N. G., Krokhin, O. N., Popov, Yu. M.

TITLE: Production of states with negative temperature in the p-n-junctions of degenerate semiconductors

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1879-1880

TEXT: When applying a voltage in forward direction of a p-n-junction in a semiconductor the concentration of the minority carriers increases near the p-n junction. The maximum concentration of these carriers corresponds to the complete compensation of the potential barrier by an external field. It corresponds almost to that part of the crystal where the carriers are majority carriers. (In this case the p-n junction is regarded as a sharp junction). The negative temperature in the band-to-band transitions occurs only when the Fermi quasi-levels corresponding to the non-equilibrium concentrations of the electrons and holes satisfy the condition: $\mu_e + \mu_p > \Delta$ (1). In this case μ_e and μ_p denote the Fermi

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Production of states with negative ... S/056/61/040/006/029/031 B125/B202

"quasi-levels" of the electrons and holes, and Δ the width of the forbidden band. When applying a voltage in forward direction to a p-n junction the carriers must be degenerate at least in one part of the p-n junction. Semiconductors with such p-n junctions proved to be tunnel diodes, the mechanism of the occurrence of these states with negative temperature studied here does not correspond to the tunnel part but to the volt-ampere part of the characteristics of the tunnel diode. In the p-n junctions of the strongly degenerate semiconductors a state with negative temperature occurs before the potential barrier is completely compensated. Therefore, the dispersion theory of a current passing through a p-n junction can be used for qualitative estimations. The minimum value of the external voltage U_{min} at which a state with negative energy still occurs, is $U_{min} = \Delta/e$ where e is the charge of the electron. The order of magnitude of the current density is $I \sim -(eDn_p/L)\exp(eU/kT)$ where D denotes the diffusion coefficient, L the diffusion length, and n_p the electron density in the p-range of the semiconductor. The current density decreases with increasing degeneracy and also with decreasing

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temperature of the sample. For this reason a state with negative energy may be attained under steady operation. The spatial region in which a state with negative temperature occurs, is formed in the layer near the p-n junction with a density of the order of magnitude of one diffusion length. The high densities of the majority carriers surrounding the range of negative temperatures in the degenerate semiconductors can be used as radiation-reflecting surface, i.e., as resonator. The current density can be reduced if the semiconductors forming a p-n junction have different widths of the forbidden bands. For the observation of a negative temperature it is recommended to study the change of the volt-ampere characteristics on irradiation of the junction with the light of the corresponding frequency. There are 4 references: 3 Soviet-bloc and 2 non-Soviet-bloc. The two references to English-language publications read as follows: L. Esaki. Phys. Rev., 109, 603, 1958; J. I. Pankove, Phys. Rev. Lett., 4, 20, 1960.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: April 18, 1961

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25210

6.3300

S/056/61/040/006/031/031
B125/B202

AUTHORS: Basov, N. G., Osipov, B. D., Khvoshchev, A. N.

TITLE: Recombination luminescence of indium antimonide in an avalanche breakdown

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1882

TEXT: When studying the behavior of the crystals of indium antimonide in strong electric fields it was found that at a field strength of ~200 v/cm the carrier concentration strongly increases as a result of impact ionization of the electrons of the valence band (avalanche breakdown). (M. Glicksman, M. C. Steele. Phys.Rev., 110, 1204, 1958; M. C. Steele, M. Glicksman. J. Phys.Chem. Solids, 8, 242, 1959; A.C.Prior. J.Electr. and Control., 4, 165, 1958). The authors deal with an infrared luminescence of the crystals of n-type indium antimonide with low impurity concentrations on applying current pulses of up to 100 amperes/mm^2. With such amperages the resistance of the specimen was reduced by more than one order of magnitude with respect to the resistance at low amperages. This

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Recombination luminescence of indium ... S/056/61/040/006/031/031
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may be due to an avalanche breakdown. To avoid overheating of the specimen current pulses of 3 microseconds at the maximum with a repetition frequency of 50 cps are used. Luminescence was observed at a temperature of 78°K. It disappeared on heating the specimen to 120 - 180°K. The increase and decrease of the light pulse took less than one microsecond so that the luminescence observed cannot be connected with the heating of the crystal lattice. The radiation spectrum with the maximum at $\lambda = 5.3\mu$ and the half-width 0.25μ suggests that in this case recombination luminescence is concerned. (T.S. Moss. Optical Properties of Semiconductors, 1959). The actual temperature at the maximum of the spectrum was determined by comparing it with the radiation of a black body. It was found to be 500°K. The authors thank D. N. Nasledov and his collaborators for their interest. [Abstracter's note: Complete translation.] There are 4 non-Soviet-bloc references. The two most recent references to English-language publications read as follows: M.C. Steele, M. Glicksman. J.Phys. Chem.Solids, 8, 242, 1959; T.S. Moss. Optical Properties of Semiconductors, 1959.

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Recombination luminescence of indium ... S/056/61/040/006/031/031
B125/B202

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Institute of Physics imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: April 27, 1961

Card 3/3

9.4177 (113С)

28767
S/056/61/041/003/020/020
B113/B102

AUTHORS: Basov, N. G., Krokhin, O. N., Lisitsyn, L. M., Markin, Ye.P., Osipov, B. D.

TITLE: Negative conductivity in induced transitions

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 3(9), 1961, 988-989

TEXT: In indirect transitions the carrier concentration at which a negative temperature occurs relative to the band-to-band transition, is comparatively small. It is by some orders of magnitude lower than the concentration at which a negative absorption coefficient exists for photons with an energy that is comparable with the width of the forbidden band. For the existence of a negative absorption coefficient it is necessary that the probability of induced photon emission in the band-to-band transition considerably exceeds the photon absorption probability in the inverse process in order to compensate also absorption in inner transitions. The processes, however, that are connected with internal absorption practically do not influence conductivity since they do not change the

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Negative conductivity in induced... S/056/61/041/003/020/020
B113/B102

total number of free carriers. The band-to-band transitions which are in a state with negative temperature and which were induced by photon irradiation, reduce the number of free carriers and lead to a decrease in conductivity. Hence, the semiconductor which is in a state with negative temperature relative to the band-to-band transition is bound to have negative photoconductivity when irradiated with photons, whose energy is almost equal to the width of the forbidden band. The measurement of the spectral dependence of the semiconductor photoconductivity permits the determination of the states with negative temperatures also with lacking negative absorption coefficient. The authors made experiments for the production and observation of states with negative temperature in silicon. The specimen was irradiated at 4°K with light of a wavelength smaller than 0.7 μ which considerably increased its conductivity. Upon additional irradiation with weak monochromatic light a conductivity reduction (negative photoconductivity) was observed for a series of specimens in a narrow band of wavelengths near 1.1 μ. It can be assumed that the conductivity decrease observed is due to the existence of a state with negative temperature. However, also other explanations, such as impurity photoconductivity, are possible. [Abstracter's note: Essentially

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Negative conductivity in induced... S/056/61/041/003/020/020
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complete translation.] There are 3 Soviet references.

ASSOCIATION: Fizicheskiy institut im. P. N. Lebedeva Akademii nauk SSSR (Physics Institute imeni P. N. Lebedev of the Academy of Sciences USSR)

SUBMITTED: July 13, 1961

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9.3592, ... 1538, 1057

27483
S/053/61/075/001/001/003
B125/B108

AUTHORS: Basov, N. G., Krokhin, O. N., Orayevskiy, A. N., Strakhovskiy, G. M., Chikhachev, B. M.

TITLE: Investigation of relativistic effects with the aid of molecular and atomic frequency standards

PERIODICAL: Uspekhi fizicheskikh nauk, v. 75, no. 1, 1961, 3 - 59

TEXT: The present paper gives a survey of experiments verifying the general theory of relativity, some problems in special relativity theory, and cosmological hypotheses by means of molecular and atomic frequency standards. V. L. Ginzburg (UFN, 59, 11 (1956); sb. "Eynshteyn i sovremennaya fizika", M., Gostekhizdat, 1956, str. 93 - 139) made suggestions for the experimental verification of general relativity theory. By means of cesium frequency standards with two separate resonators, an absolute frequency stability of $\pm 1.5 \cdot 10^{-10}$ was attained. A further improvement of the stability of cesium standards requires the use of narrower spectral lines. With slow molecule beams, an absolute stability

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of up to 10^{-12} was reached. A certain increase of stability may be attained using a beam of thallium atoms instead of cesium. Up to now, however, the authors have no information on such use of thallium. The electrical resonance method, i. e., the use of spectral lines of a molecular beam caused by transitions between rotational levels, guarantees the same stability as in cesium standards. The frequency standards relying on spectral lines of monatomic alkaline metals permit very sensitive indications. Quartz resonators, too, give a stability of 10^{-10} and, when immersed in liquid helium, even of 10^{-11}. The power of molecular generators has to be amplified by means of a low-noise amplifier (e. g., ЛБВ(LBV)) and an amplifying klystron. Self-tuning is necessary for high-precision frequency measurements. In measurements of the gravitational frequency shift by means of molecular generators on board of artificial satellites, the influence of the first order Doppler effect has to be eliminated. This can be done, for instance, by an exact measurement of long time intervals on the Earth and on the satellite with subsequent comparison by radiocommunication. Another method of this kind is based on the mixing of a signal emitted from the Earth (frequency f) with the signal

of a molecular generator on the satellite (frequency 2f). Ionospheric and tropospheric fluctuations have to be taken into account. Measurements of the gravitational shift of frequency are being prepared (Sci. News Lett., 76, 35 (July 18, 1959)). The gravitational shift may be measured from two points of different altitude on the Earth's surface (mountain) without the use of satellites and, therefore, without consideration of the Doppler effect of first and second order. For H = 3.2 km and f = 10^{10} cps, $\Delta f = 3.4 \cdot 10^{-3}$ cps. At present, two first-order experiments are known for the verification of special relativity theory. In one of them (proposed by Møller and carried out by Townes), two inversely directed beams of excited ammonia molecules were sent toward each other through the horizontal resonators of two molecular generators mounted on a rotatable plate. The expected frequency deviations were not found in these experiments. The other first-order experiment with respect to (v/c) is based on the measurement of the phase difference of two nonsynchronized molecular generators placed on a rotatable base at a distance of a few meters. Some cosmological effects may be verified experimentally by means of highly stable atomic clocks. An idea of V. A. Fok (G. M. Strakhovskiy, Doklad na Lomonosovskikh chteniyakh v MGU, 1958) concerning singular reference
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Investigation of relativistic effects... S/053/61/075/001/001/003
B125/B108

systems is mentioned. The variations of the gravitational constant ($\delta g \approx g.10^{-10}$ within a year, according to Dirac) can be verified by comparing the motion of a high-precision atomic clock with the revolution period of an Earth satellite. The eccentricity of the Earth's orbit may also have an influence on the gravitational constant. The hypothetical time dependence $\delta\alpha/\alpha \sim 10^{-2}\, \delta g/g$ of the fine structure constant α (L. D. Landau et al., DAN SSSR, 95, 497, 773, 1177 (1954)) can be verified experimentally by comparing the motion of two atomic clocks of different types. The character of gravitation may be determined by another series of experiments. There are 31 figures and 113 references: 47 Soviet and 66 non-Soviet. The three most recent references to English-language publications read as follows: Missiles and Rockets, No. 1, 1961, p. 34; B. Hoffmann, Phys. Rev. 121, 337 (1961); S. M. Bergmann, J. Appl. Phys. 31, 275 (1960).

Card 4/4

BASOV, Nikolay Gennadiyevich; OSIPOV, B. D.; KHVOSHCHEV, A. N.

"State with Negative Temperature in Electron Hole Plasma Compressed by Its Own Magnetic Field"

Paper presented at Optical Society of America Meeting, Washington, D. C. 14-17 March 62

BASOV, Nikolay Gennadiyevich; KRUKOV; ZUYEV, V. S.

"Increase of Power of Pulsed Ruby Optical Quantum Generator by Modulation of Resonator Quality Factor"

Paper presented at Optical Society of America Meeting, Washington, D. C. 14-17 March 62

L 11085-63 EEC(b)-2/EWT(l)/EWG(k)/BDS--AFFTC/ASD/ESD-3--Pz-4--
AT/IJP(C)
ACCESSION NR: AT3002986 S/2927/62/000/000/0093/0095

64

AUTHOR: Basov, N. G.; Krokhin, O. N.; Popov, Yu. M.

TITLE: State with negative temperature in p-n transitions of degenerate semiconductors

SOURCE: Elektronno-dyrochnyye perekhody v poluprovodnikakh. Tashkent, Izd-vo AN UzSSR, 1962, 93-95

TOPIC TAGS: semiconductor negative temperature, population inversion, semiconductor interband transition, negative absorption coefficient

ABSTRACT: Population inversion with respect to interband transitions is possible only if at least one type of carrier is degenerate. Since transitions of this type are referred to the diffusive portion of the volt-ampere characteristic, negative temperature can be expected in a region, near the p-n transition, whose thickness is of the order of the diffusion length. Although cryogenic treatment can produce a population inversion at any value of current density, however small, a comparatively high nonequilibrium concentration of minority carriers is necessary to bring the value of the

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